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AUTHOR Mussnug, Kenneth J.; Craig, James R.
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ABSTRACT

To evaluate the instructional effectiveness of the introductory portion of a modularized competency-based vocational education (CBVE) drafting program, achievement of students participating in this program were compared to students receiving traditional drafting instruction. Research participants were female and male juniors and seniors in their first year of drafting at one of six vocational schools in west central Kentucky. Fourteen instructional modules were used in the CBVE drafting instructional program. Two dependent variables were used in the analysis: the cognitive posttest of drafting knowledge and the psychomotor test of drafting abilities. The multiple regression analysis indicated significant effects due to teaching method for the total group. Analysis of the posttest scores supported the interpretation that good students appeared to do well regardless of the teaching methods used, whereas CBVE may have its most pronounced effects in lower ability students. The CBVE students displayed significantly higher achievement on the drafting posttest. The on and below the median group appeared to benefit most from the CBVE instruction. CBVE instruction appeared to have best addressed the correct line weights and visualization skills required to solve drafting problems. (YLB)

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An Evaluation of the Effectiveness of a Competency Based Vocational Education Drafting Program

Kenneth J. Mussnug
Russellville Vocational School
Russellville, KY

James R. Craig
Department of Psychology
Western Kentucky University

In the late 1970s and early 1980s, because of increased public interest in accountability of educational programs, there was a movement in vocational education toward Competency Based Vocational Education (CBVE) -- an instructional system designed to align vocational programs with actual job requirements. Spillman and Bruce (1978) explained the accountability movement as follows:

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> Students were leaving school without the basic skills necessary to function as contributing members of society and parents were asking potentially embarrassing questions about accountability. The questions asked raise some very basic issues. What should be included in the school curriculum? How can educators be sure they have planned the right curriculum? How will teachers determine that students have attained the objectives? In summary, how can we as educators answer our critics on the question of accountability?. Competency based education has emerged as one approach (Spillman & Bruce, 1976, p. 7).

The Vocational Education Act of 1963 and its 1968 and 1976 amendments tied instruction to accountability. The implications of the acts were that vocational education programs must be responsible for the results produced in the intended learners. Evidence of the outcomes produced in the learners had to be tied to instruction AND directly related to the vocational skills the program was designed

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to impart. Competency based instruction seemed naturally suited to the situation since it focuses on mastery and facilitating student achievement through the application of the basic principles of learning.

CBVE can be defined as an educational program in which the competencies (i.e., skills) to be acquired and demonstrated by the student as well as the criteria to be applied in assessing the competencies are made explicit. The student is held accountable for meeting those criteria. CBVE is based on tasks workers perform on the job and which have been validated and kept up-to-date through job task surveys. Although modules or learning packets are frequently used in CBVE programs, the two techniques are not synonymous. Modules serve as a delivery system designed to individualize instruction.

While no data based studies of CBVE drafting programs were located in a review of the research literature, related research was located.

Personalized Systems of Instruction (PSI)

Two studies in vocational education have reported on the positive effects of PSI on student achievement. Oen and Sweeney (cited in Blank, 1980) compared an individualized learning procedure with a lecture/discussion method in seven content areas. The results indicated that students scored significantly higher in five of the seven

areas. Bushnell (cited in Blank, 1980) compared an experimental individualized instruction method to a traditional approach for the upgrade training of journeymen electricians. The findings indicated that PSI produced significantly better student achievement.

In a related study, Born, Gledhill, and Davis (1972) conducted a study to compare student achievement in lecture/discussion and PSI in a higher education setting. The achievement of students in the PSI section was found to be superior to that of students in the lecture section. An analysis of class section achievement by item types revealed that students in the lecture section scored lower on all item types with the greatest differences occurring on items that required written responses. An analysis of student achievement in the class across the instructional procedures suggested that PSI had its greatest impact on students with "average" to "poor" academic records. Thus, it would appear that the major contribution of personalized instructional procedures is that they develop higher levels of excellence in "good" to "poor" students -- a result that tends to justify top heavy letter grade distributions. Born et al. also noted that the possibility exists that performance in personalized courses in higher education is superior on the average because academically poorer students tend to withdraw from classes taught in this

manner. However, Fernald and Du Nann (1972) have reported somewhat different findings.

Fernald and Du Nann (1972) compared the mastery and study behavior of low and high achieving students in both a PSI and lecture/discussion course. They found that students receiving individualized instruction out performed those receiving conventional instruction. However, they also found that PSI was equally beneficial for both low and high achieving students in increased achievement and mastery. The PSI students indicated significant improvement in their study behaviors in that they became more proficient in evaluating their mastery of subject matter and that learned to become their own feedback monitors.

Student Achievement Under CBVE Programs

Student achievement in CBVE versus traditional vocational education instruction programs in Kentucky has been examined by Vincent and Cobb (cited in Graham, 1977) for three occupational areas: bank teller, secretary, and tractor mechanic. They found that in three situations CBVE students scored significantly higher than traditionally taught students on tests designed to measure cognitive skills. In two of the remaining situations, CBVE students scored higher than other students but not significantly so. Disregarding one secretarial group which was not comparable

to the other groups, Vincent and Cobb concluded that CBVE students learn more, at a faster rate than students in traditionally taught programs and are better able to perform entry-level skills demanded by employers than are students in traditional programs.

Blank (1980) summarized eight studies in which various approaches to CBVE were compared with more traditional instructor-centered approaches to vocational education. Based on his literature review, Blank reached the conclusion that CBVE, when well designed and implemented, will allow students to reach a higher level of mastery and yield additional student-related benefits such as meeting needs of special learners, providing early successes, reducing absenteeism, and greater accountability of students and the program. He concluded that CBVE was better than instructor-centered approaches in vocational education.

Purpose

The purpose of this study was to investigate achievement of students experiencing a CBVE modularized drafting program compared to students experiencing traditional drafting instruction. Student achievement was examined at the entry level area of mechanical drafting. If the drafting modules can be shown to be an effective method of individualizing the CBVE program and if the

students demonstrate greater achievement under a CBVE individualized drafting program than under traditional drafting instruction, there will be evidence to support the use of this instructional method. This research has attempted to evaluate the instructional effectiveness of the introductory portion of a modularized CBVE drafting program.

Method

Participants

The research participants were 15 female and 49 male high school students 29 of whom were juniors and 35 of whom were seniors in their first year of vocational drafting. The students were attending one of six vocational schools located in west central Kentucky. Thirty students were enrolled in one of three CBVE modularized drafting instruction programs while 34 students were enrolled in one of three traditional instruction drafting programs. The students were informed of the purpose of the study, the reasons for administering the various tests, and that their test scores would not affect their classroom grade.

CBVE Instructional Materials

Thirteen instructional modules covering introductory mechanical drafting were used in the CBVE drafting instruction program. Each module contained an introduction, directions, objectives, check-out activities,

learning activities, an instructor's final checklist, and student self checks. The modules and slide tape presentation titles are presented in Table 1.

TABLE 1

MODULE AND SLIDE TAPE TITLES

NUMBER & NAME	SLIDE TAPE:
1. DRAFTING - AN INTRODUCTION	1.1 Drafting, an Introduction
2. USING THE DRAFTING EQUIPMENT	2.1 Drafting Equipment 2.2 Using the Equipment
3. USING THE DRAFTING MACHINE	3.1 Using the Drafting Machine
4. USING THE DRAFTING SCALES	4.1 Using the Drafting Scales
5. LETTERING	5.1 Lettering
6. GEOMETRIC CONSTRUCTION	6.1 Geometric Shapes 6.2 Geometric Problems 6-2 6.3 Geometric Problems 6-3 6.4 Geometric Problems 6-4 6.5 Geometric Problems 6-5 6.6 Geometric Problems 6-6
7. MAKING ONE VIEW DRAWINGS	
8. LEARNING TO VISUALIZE	8.1 Learning to Visualize 8.2 Orthographic Projection 8.4 Three View Problems
9. DIMENSIONING	9.1 Dimensioning
10. DRAWING FROM SKETCHES	
11. DRAWING SECTIONS	11.1 Sections
12. DRAWING AUXILIARIES	12.1 Auxiliaries
13. DRAWING ISOMETRICS	13.1 Isometrics
14. DRAWING OBLIQUES	14.1 Obliques

The modules covered the tasks used in both the CBVE and traditional instructional programs. Although it was anticipated that most students would complete seven to nine modules in the time allotted, the instructors were provided with Modules 1 through 14.

Instrumentation

The General Aptitude Test Battery (GATB) spatial section. The GATB spatial section was used to measure the student's spatial ability. It has been suggested that spatial ability is a factor in learning to visualize (Conger, 1977). The GATB test authors, using a validation sample of 232 workers, and a cross validation sample of 60 workers, validated a spatial score of 115 as the minimum for employed drafters. Approximately six minutes were required to administer the GATB spatial test.

Tests of Adult Basic Education (TABE) Level D -- Reading. Reading level was assessed using the TABE Level D. Level D is the most difficult version of the TABE and was adapted from the California Achievement Test for adult usage. The reliability of the TABE forms has been assessed and determined to be acceptable using a test-retest procedure and the Kuder-Richardson formula for internal consistency (Publisher's Testing Service, 1976). Approximately six minutes were required to administer the reading vocabulary section and 60 minutes to administer the reading comprehension section of the TABE.

Tests of Adult Basic Education (TABE) Level D -- Mathematics. Mathematical ability was assessed using the TABE Level D. The reliability of the TABE mathematics reasoning section has been assessed using a test-retest

procedure and the Kuder-Richardson formula for internal consistancy (Publisher's Testing Service, 1976). Approximately 31 minutes were required to administer the mathematics reasoning section of the TABE.

Pretest to assess prior knowledge of drafting. The pretest to assess prior knowledge of drafting consisted of 29 multiple choice and 14 fill-in-the-blank questions. The raw scores were converted to percent scores prior to analysis. To assess validity, the test was administered to a group of drafting students who were in their first and second years of vocational drafting and who were not involved in the study. The correlation between the students' grade point averages in drafting and the pretest was .65. The test required less than fifteen minutes to complete.

Posttest to assess student cognitive achievement. The posttest of cognitive achievement consisted of 26 multiple choice, 11 matching, and 15 fill-in-the-blank items. The raw scores were converted to percent scores prior to analysis. The posttest was also administered to the group of drafting students not involved in the study. The correlation between the students' achievement test scores and grade point averages in drafting were found to be .79. The questions were completed in less than 30 minutes.

Posttest to assess students psychomotor drafting

ability. Two problems were selected to evaluate psychomotor drafting abilities (i.e., linework, lettering, placement of dimensions, and solution of the problem) and were validated on the group of drafting students not participating in the study. A total score was calculated from the sum of the four scores. A correlation of .63 was found between the students' grade point averages in drafting and scores on the test. A time of one hour and 40 minutes was allotted for the completion of the first problem and 45 minutes for the second.

Three industrial drafters graded the drawing problems. The reliability among the three graders ranged from r = .773 to r = .938. Therefore, an average of the three grader's scores for each category was used in the analysis.

Data Collection

During the first two weeks of the semester, the students were administered the GATB spatial test, the pretest of drafting knowledge, TABE reading comprehension and reading vocabulary, and TABE arithmetic reasoning tests and demographic data were obtained. During each visit, a task list provided by the Kentucky Department of Vocational Education (and identical to the list used to develop the modules) was presented to all of the teachers involved in the study. Each instructor verified his program was addressing all the tasks on the list. Each school was

visited again in December, 1982, to obtain the posttest data.

Results

Two dependent variables were used in the analysis: the cognitive posttest of drafting knowledge and the psychomotor test of drafting abilities which produced five scores -- linework, solution of the problem, placement of the dimensions, lettering, and total. The basic hypothesis examined was, that after removing the effect of spatial ability, reading ability, mathematical ability, year in school, and prior drafting knowledge, students who experience a CBVE instruction drafting program will not demonstrate greater drafting achievement than students who experience a traditional instruction method.

Using regression, analyses were conducted for the total group of students, for the males only, for those who scored on and below the median on a dependent variable, and for those who scored above the median on a dependent variable. The results of these analyses are summarized for each dependent variable in Tables 2 through 8 below.

Posttest of Drafting Knowledge

The regression analyses revealed that the pretest and total reading scores accounted for large percentages of variance in the posttest scores for the total group, males only, below the median, and above the median group analysis

(see Table 2). Furthermore, in each instance, a significant portion of the remaining variance in the posttest scores was related to teaching method. In each case, the CBVE group was found to score higher than the traditional group.

TABLE 2

PERCENTAGE OF VARIANCE
BY
VARIABLES REMOVED
MULTIPLE REGRESSION ANALYSIS
POSTTEST OF DRAFTING KNOWLEDGE

VARIABLES REMOVED	PERCENTAGE OF VARIANCE TOTAL GROUP	MALES ONLY	BELOW THE MEDIAN	ABOVE THE MEDIAN
GATB	##	##	##	##
PRETEST	49.03	48.69	9.93	5.02
SEX	##	##	##	##
READING V.	##	##	##	##
READING C.	##	##	##	##
READING T.	11.46	12.58	22.82	31.13
YEAR IN SCH.	##	##	##	##
MATH REAS.	##	##	##	##
INSTR. METHOD	4.32 **	4.50 *	10.27 *	10.00 *

** <.01 * <.05 -- Not Significant
accounts for less than 1% of the variance

Linework

For the linework portion of the drafting skills psychomotor test, the regression analyses indicated a

significant effect of teaching method for only the below the median group analysis (refer to Table 3). In that

TABLE 3

PERCENTAGE OF VARIANCE
BY
VARIABLES REMOVED
MULTIPLE REGRESSION ANALYSIS
LINEWORK

VARIABLES REMOVED	PERCENTAGE OF VARIANCE TOTAL GROUP	MALES ONLY	BELOW THE MEDIAN	ABOVE THE MEDIAN
GATB	21.22	15.04	##	##
PRETEST	##	##	##	##
SEX	16.52	##	##	3.66
READING C.	##	##	##	##
READING V.	##	##	##	##
READING T.	##	##	##	11.92
YEAR IN SCH.	##	##	15.72	##
MATH. REAS.	##	1.77	20.05	2.01
INSTR. METHOD	3.51 --	2.56 --	14.22 **	.52 --

** <.01 * <.05 -- Not Significant
accounts for less than 1% of the variance

instance, a significant amount of variance in the linework score was related to the type of teaching method, after removing the effect of mathematical reasoning and year in school, with the CBVE instructed students performing at a higher level than the traditionally instructed students. In the total group, males only, and above the median

analysis, there was no significant effect of teaching method after removing the effects of demographic and ability variables.

Solution of the Problem

TABLE 4

PERCENTAGE OF VARIANCE
BY
VARIABLES REMOVED
MULTIPLE REGRESSION ANALYSIS
SOLUTION OF THE PROBLEM

VARIABLES REMOVED	PERCENTAGE OF VARIANCE TOTAL GROUP	MALES ONLY	BELOW THE MEDIAN	ABOVE THE MEDIAN
GATB	5.61	12.31	##	##
PRETEST	##	##	##	3.66
SEX	18.28	##	15.10	##
READING V.	##	##	##	7.37
READING C.	##	##	##	##
READING T.	##	##	##	##
YEAR IN SCH.	##	##	##	##
MATH. REAS.	10.39	3.03	14.09	##
INSTR. METHOD	10.39 **	10.41 *	19.86 **	4.74 --

** <.01 * <.05 -- Not Significant
accounts for less than 1% of the variance

In the solution of the problem portion of the drafting skills psychomotor test, the regression analyses indicated a significant effect of teaching method for the total group, the males only, and the below the median group

analysis (see Table 4). After removing the effects of spatial ability, mathematics reasoning, and sex for the total group, spatial ability and mathematics reasoning for the males only group, and sex and mathematics reasoning for the below the median group, a significant amount of variance in the linework scores was found to be related to the type of teaching method. Specifically, the CBVE instructed students performed at a higher level than the traditionally instructed students. The above the median group analysis indicated there was no significant effect of teaching method after removing the effects of the demographic and ability variables.

Placement of Dimensions

For the placement of dimensions portion of the drafting skills psychomotor test, the regression analyses indicated there was no significant effect of teaching method for any of the groups after removing the effects of the demographic and ability variables (refer to Table 5).

Lettering

For the lettering portion of the drafting skills psychomotor test, the regression analyses indicated there was no significant effect of teaching method for any of the groups after removing the demographic and ability variables (see Table 6).

TABLE 5

PERCENTAGE OF VARIANCE
BY
VARIABLES REMOVED
MULTIPLE REGRESSION ANALYSIS
PLACEMENT OF DIMENSIONS

VARIABLES REMOVED	PERCENTAGE OF VARIANCE TOTAL GROUP	MALES ONLY	BELOW THE MEDIAN	ABOVE THE MEDIAN
GATB	14.30	24.68	15.53	##
PRETEST	##	##	##	##
SEX	1.43	##	##	5.57
READING V.	##	##	##	##
READING C.	##	##	##	3.87
READING T.	##	##	##	##
YEAR IN SCH.	##	##	##	##
MATH. REAS.	##	##	##	9.90
INSTR. METHOD	1.56 --	2.34 --	5.08 --	2.35 --

** <.01 * <.05 -- Not Significant
accounts for less than 1% of the variance

TABLE 6

PERCENTAGE OF VARIANCE
BY
VARIABLES REMOVED
MULTIPLE REGRESSION ANALYSIS
LETTERING

VARIABLES REMOVED	PERCENTAGE OF VARIANCE TOTAL GROUP	MALES ONLY	BELOW THE MEDIAN	ABOVE THE MEDIAN
GATB	14.98	13.33	##	##
PRETEST	##	2.78	8.46	6.58
SEX	##	##	##	##
READING V.	##	##	##	3.15
READING C.	2.97	##	##	##
READING T.	2.23	##	40.57	##
YEAR IN SCH.	##	##	##	1.34
MATH REAS.	##	##	##	##
INSTR. METHOD	1.42 --	1.34 --	.30 --	1.74 --

** <.01 * <.05 -- Not Significant
accounts for less than 1% of the variance

Drafting Total Scores

The regression analysis for the drafting total scores indicated a significant effect of teaching method for only the total group analysis (refer to Table 7). In that instance, a significant amount of variance in the drafting total scores was related to the type of teaching method, after removing the effects of spatial ability and sex, with the CBVE instructed students performing at a higher level

than the traditionally instructed students. There was no significant effect of teaching method after removing the effects of demographic and ability variables for the males only, the below the median, or the above the median analyses.

TABLE 7

PERCENTAGE OF VARIANCE
BY
VARIABLES REMOVED
MULTIPLE REGRESSION ANALYSIS
DRAFTING TOTAL SCORES

VARIABLES REMOVED	PERCENTAGE OF VARIANCE TOTAL GROUP	MALES ONLY	BELOW THE MEDIAN	ABOVE THE MEDIAN
GATB	22.40	21.25	1.79	1.19
PRETEST	##	##	##	##
SEX	10.96	##	##	##
READING V.	##	##	##	##
READING C.	##	##	27.18	##
READING T.	##	##	##	2.50
YEAR IN SCH.	##	##	18.28	##
MATH REAS.	##	##	##	##
INSTR. METHOD	5.60 *	5.06 --	1.23 --	.65 --

** <.01 * <.05 -- Not Significant
accounts for less than 1% of the variance

TABLE 8

SUMMARY OF THE FINDINGS

	MULTIPLE REGRESSION ANALYSES FOR THE DEPENDENT VARIABLES			
	TOTAL	MALES	BELOW Mdn.	ABOVE Mdn.
POST-TEST	**	*	*	*
LINEWORK	---	---	**	---
SOLUTION	**	*	**	---
DIMENSIONS	---	---	---	---
LETTERING	---	---	---	---
TOTAL	*	---	---	---

** <.01 * <.05 --- Not significant

Discussion

Although the multiple regression analysis indicated significant effects due to teaching method for the total group, this analysis may be misleading in that it does not address important individual differences or pinpoint the location where CBVE is having the most pronounced effect. Good students appear to do well regardless of the teaching methods used whereas CBVE may have its most pronounced effects in the lower ability students. The later interpretation is supported by the analysis of the posttest achievement scores.

The students who experienced the CBVE instruction method display significantly higher achievement on the

drafting posttest, after the effects of selected characteristics were removed, for all of the groups analyzed -- the total group, the males only group, the on and below the median group, and the above the median group. The group which appeared to benefit most from the CBVE instruction was the on and below the median group -- a finding similar to those reported by Hursh (1976), Keller (1968), and Born et al. (1972) in that PSI-type instruction has the greatest impact on the good to poor students. Reading ability and prior drafting knowledge were the primary factors, other than instruction method, that seemed to influence the achievement test scores. Perhaps the inclusion of alternative readings within the instructional modules, such as the student self checks or instruction sheets, helped the CBVE students. The self checks provide the students with a practice test over the materials, thus, enabling them to become their own feedback monitors and better retain the cognitive information -- an interpretation also supported by Hursh (1976). In addition, the information sheets may have provided alternative reading opportunities for the CBVE students not available to the traditionally instructed students.

The on and below the median students experiencing the CBVE program appear to have learned the correct line weights better than the on and below the median students

experiencing the traditional instruction method. This result may have been due to the presentation of the drafting lines within the modules, the slide-tapes and the text assignment. The triple presentation may have helped these students better retain the correct line weights -- a finding which lends support to the use of multi-media presentations in a CBVE modularized program.

Another interesting finding is that the CBVE instruction appears to have better addressed the visualization skills required to solve drafting problems than than did the traditional instruction. The teaching method had a much more pronounced effect on student achievement than did GATB spatial scores or any of the other variables analyzed, particularly for the on and below the median students. Teaching method accounting for 20 percent of the variance for this group and for over ten percent of the variance in both the total group and males only analysis. The skill of visualization is heavily stressed in the CBVE modules. Although the analysis did not specifically address the question of student differences for those using the slide tape presentations and those not using the slide tapes, it is possible that the heavy concentration of the audio-visual presentations along with the student self checks and information sheets may have helped the CBVE students develop better

visualization skills than traditionally instructed students. Thus, it seems that several alternative learning opportunities should be used in vocational drafting programs to allow students options in choosing their instructional sequence. These multi-media and alternative learning opportunities should include instruction and information sheets, student self checks, practice problems, and audio-visual presentations. Special emphasis should be placed on slide-tape presentations which should be developed to permit the good to poor students to adequately master the competencies.

It is interesting to note that the type of instruction students experience did not seem to affect dimensioning or lettering skills. It appears that the relatively short time duration between the pretest and posttest may have been a primary factor. Specifically, dimensioning is normally covered during and after the skill of visualization and it appears there was not sufficient time to adequately address this competency prior to the administration of the posttest. Likewise, lettering is a skill which requires many hours of practice. Although lettering was instructed early in both programs, the four month duration of the study was probably an insufficient amount of time for any differences between the two instructional groups to occur. None of the variables

appeared to be strongly related to lettering ability.

The findings point to the potential for CBVE instruction to be an effective method for teaching drafting and demonstrate that CBVE drafting instruction may have a stronger effect on learning than many personal characteristics. The findings also suggest that the use of cutoff scores on the GATB spatial test to determine admittance into drafting programs may be based on the false assumption that student achievement in drafting is directly related to spatial ability. Certainly, the findings indicate that the instruction method has a stronger effect on solution skills than spatial ability as measured by the GATB. In fact, reading ability and mathematics reasoning ability also seem to have a strong effect on solution of drafting problems. Therefore, student selection for vocational drafting programs should be based on a variety of selected criteria rather than a particular spatial ability score.

Future research should be conducted to answer many as yet unanswered questions in this area. For instance, the parts of a modular program should be examined to determine which components have the strongest influence on the students scoring on and below the median in CBVE programs. This group appears to be the most influenced by the CBVE approach and research to show the factors involved in

student achievement should be conducted. The information sheets, student self checks, and audio visual presentations may have the strongest influence on this group according to several sources in the literature. However, most of this research has been conducted in higher education where the good to poor students may by removed as a result of various educational and socio-economic factors and may not be applicable to vocational education where more good to poor students are enrolled in the various programs.

Research should also be conducted to assess the influence of reading ability on student achievement in drafting, particularly for the good to poor students. It appears that reading ability has a strong impact on learning and research on alternative reading assignments or multi-media instructional approaches for various instructional areas should be conducted.

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Footnotes

This research was conducted to meet part of the doctoral degree requirements at the University of Kentucky. All correspondence should be addressed to: Kenneth J. Mussnug, Russellville Vocational School, Russellville, KY.